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BBC TEST CARD No. 61 (FLESH TONE REFERENCE); colorimetric and other optical considerations

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Summary

Colour matching errors between a group of television cameras of the same type are normally corrected by colour trimming adjustments based on the subjective assessment of a flesh tone. Various colour references have been used for this purpose but all have certain disadvantages.

The colorimetric and optical characteristics of a new test card which provides an improved flesh tone reference, are described. This test card consists of a printed reproduction, with excellent colour fidelity, of a live model's face, produced by a modern offset lithograph process that can maintain a high standard of uniformity amongst a large number of copies. Special consideration has been given to minimizing the effects of specularly reflected light from the surface of the chart.

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1. Introduction

The portrayal of human skin colour has always been of great importance in any colour reproduction process. Departures of the reproduced chromaticity from a very restricted range of acceptable values are immediately apparent to an observer, and small changes in chromaticity between different pictures of the same subject (e.g. when viewed by different colour cameras) are also obvious. For this reason, after a neutral grey-scale balance, a "flesh tone balance" is usually carried out between the different cameras in a studio before the transmission of a programme, so that the differences in reproduced skin chromaticity due to slightly different camera analysis characteristics, gamma-correction law etc. are eliminated as far as possible. Although strictly speaking this process involves a departure from a true white balance, the adjustments involved are usually so small that the change in displayed white point between one camera and another is seldom evident.

In order to carry out this flesh tone balance, some suitable test object is clearly necessary and for this purpose a flesh tone reference test card has been developed. This report is concerned primarily with the reasons for adopting a test card in preference to other methods, and the colorimetric requirements and other optical characteristics of the card.

2. Flesh tone references

The techniques used in achieving a "flesh tone" balance vary from one broadcasting organisation to another and have included the use of live models, charts having coloured "flesh tone" chips and dummy heads sometimes provided with wigs of real hair. These techniques all suffer from one or more of the following drawbacks:—

(a) Lack of consistency; for example, a live model may acquire a sun-tan.

(b) Lack of uniformity; a live model or dummy head may show colour (and texture) changes with different angles of view, such as occur when several cameras are grouped round the object.

(c) Lack of naturalness; the process of obtaining a flesh tone balance is entirely subjective and is achieved most readily if a human subject is portrayed on the television display. The use of a test card containing colour chips has not proved satisfactory.

(d) Incorrect spectral reflection characteristic; flesh tone has a very well-defined spectral reflection characteristic which is not usually simulated with any degree of accuracy by paints or dyes used in test colour chips or in tinting dummy heads.

It was thought that a high quality picture of a human face might provide a suitable solution and consideration was given to the use of coloured photographs. However, major drawbacks with these appeared to be the difficulty in obtaining the degree of uniformity required in a large number of copies and in achieving a close enough control of colour accuracy.

Discussions with representatives of the printing industry indicated that the use of modern offset lithograph printing might enable the above drawbacks to be avoided. In this an ink printed reproduction is derived from a high quality colour transparency (or reflection print): electronically controlled colour correction can be introduced, if required, enabling a high degree of colour accuracy to be achieved. Sample prints of faces reproduced by this process were examined and spectral analyses of the flesh tones proved to be very encouraging.

Subsequently Test Card 61 (shown in monochrome in Fig. 1), produced by a similar process, has been introduced in an attempt to overcome the disadvantages of other flesh-tone references mentioned above. Careful attention to the printing process has resulted in extremely good uniformity between one card and another, while the protrayal of a live model enables the subjective flesh tone balance to be readily made. In this respect care has been taken to ensure that the picture reproduced on the television display appears as natural as possible. A suitable choice of printing inks has resulted in spectral reflectance characteristics which are substantially the same as real human skin. Because the chart is flat it presents the same appearance (apart, of course, from picture geometry) irrespective of the angle of view, provided that care is taken to avoid specular reflections of light sources from it.

3. Colorimetric characteristics

Fig. 2 shows a typical flesh tone[1] (or skin tone; the two terms are synonymous) characteristic. The steep rise in spectral reflectance over the wavelength range around 600 nm is typical of all flesh tones of whatever ethnic origin (this factor affects the luminance of the flesh tone far more than the chromaticity). The analysis characteristics, after matrixing, of a typical colour television camera are also shown in Fig. 2. These characteristics refer to "studio" scene illumination (P3000) and are normalized to equal area, representing the white balance condition.

It can be seen in general terms[2] that the output of a channel in whose spectral pass-band the reflectance ordinates

Fig. 1 - Monochrome version of Test Card 61

of a colour change rapidly with wavelength (e.g. the red channel and to a lesser extent the green channel in Fig. 2) will be affected to a greater extent by camera-to-camera changes in the shape of the analysis characteristic than a channel in which the colour's spectral reflectance ordinates change little with wavelength (e.g. the blue channel in Fig. 2). For this reason the spectral reflectance characteristic of a test object to be used in a flesh-tone balance must closely resemble that of real skin colour, for the balance between individual cameras obtained using the test object to be valid.

Fig. 3 shows a comparison between the spectral reflectance characteristics of the skin colour represented in Test Card 61 and those of two flesh tone test colours. In order to make the comparison easier the test colour ordinate values have been scaled so that the luminance values of these colours is the same as that of the test card. In fact, the test card ordinates are themselves the mean of three measurements taken on the forehead and each cheek of the face. It can be seen that a close approximation to the characteristic of true flesh tone has been obtained. The steep rise in spectral reflectance occurs at wavelengths

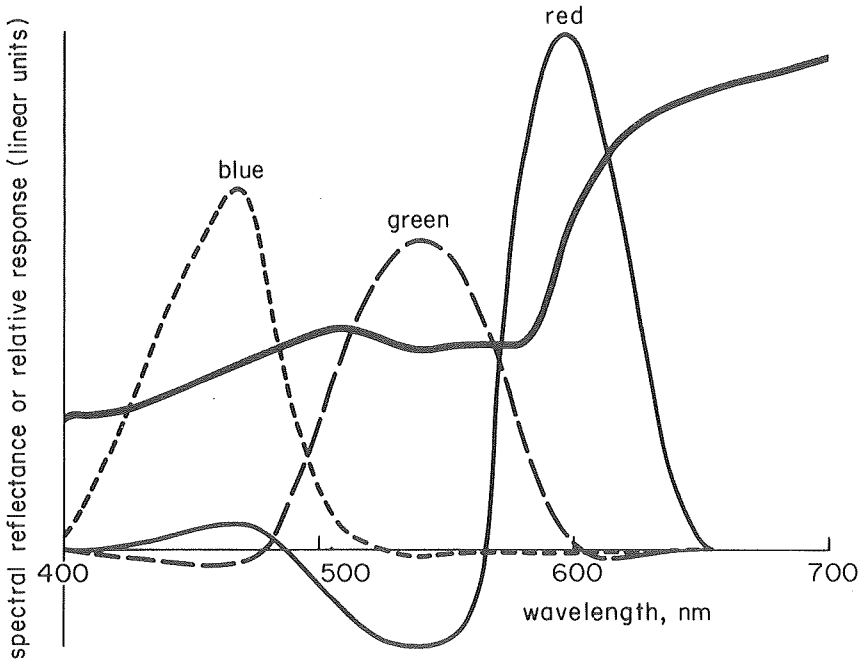

Fig. 2 - Typical flesh tone and camera analysis characteristics

Thick line . . . flesh tone
Thin lines . . . camera analysis

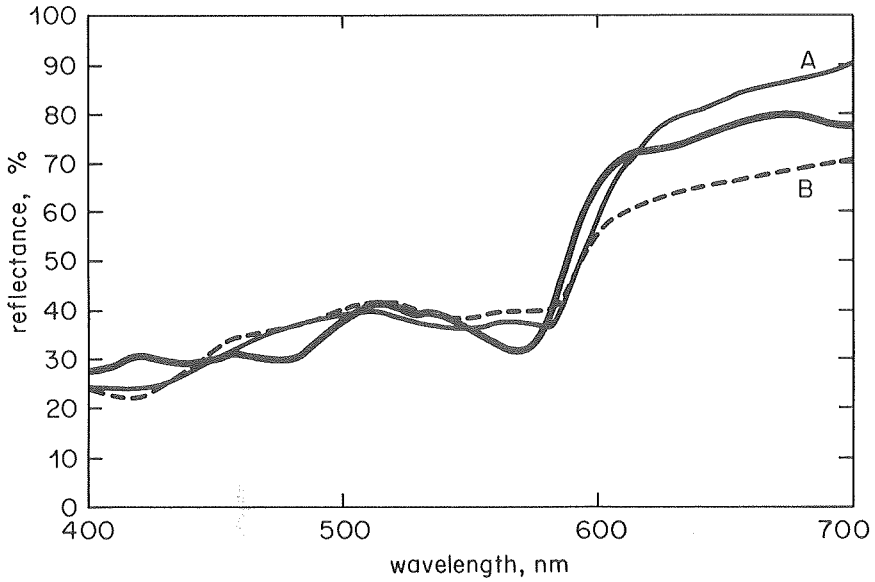

Fig. 3 - Spectral reflectance characteristics of facial area of Test Card 61 and two flesh tone test colours

Thick line . . . Test Card 61
Thin lines . . . Test colours

which are about 5 nm lower than for the equivalent reflectance value of true flesh tone, but this difference does not appear to affect to any significant extent the validity of the test card in representing flesh tone. The luminance value has been chosen so that a camera correctly exposed to a Test Chart 57 grey scale[3] (peak reflectance 60%) is also correctly exposed under the same lighting conditions to the Test Card 61 without further adjustment of the lens iris.

Fig. 4 shows the average chromaticity of the facial area of Test Card 61, compared with the eight flesh tone test colours used in assessing colour camera performance. The two test colours whose spectral reflectance ordinates are shown in Fig. 3 are also identified. It can be seen that the Test Card 61 facial chromaticity is comparable with these test colours although the dominant wavelength of the Test Card 61 chromaticity is at one extreme of the dominant wavelength range covered by the test colours.

4. The surface finish of the test card

Two conflicting requirements had to be considered in deciding the surface finish of the Test Card 61. On one hand, it was important to avoid specular reflections of studio lights and at the same time introduce as little restriction as possible on the relative positions of cameras, lights and the test chart, since there is little latitude available for the careful positioning of lights when a number of cameras are grouped around the test card. This consideration indicated the provision of a matt finish to the test card. On the other hand, it was found that light scattered from a matt surface superimposed an overall flare on the picture. The resulting low contrast ratio was found to be unacceptable, the appearance of the hair being particularly adversely affected. A glossy surface gave rise to much less flare but re-introduced the problem of specular reflections. The solution adopted was to make the card with a glossy surface but to angle the card downwards by about twenty degrees to the vertical in order to avoid specular reflections. A strut fixed to the upper edge of the Test Card enables this position to be adopted automatically when the chart is supported in front of a Test Chart 57 grey scale, as would normally be the case when making a flesh tone balance.

5. Other features of the test card

It was initially intended that the hair of the model

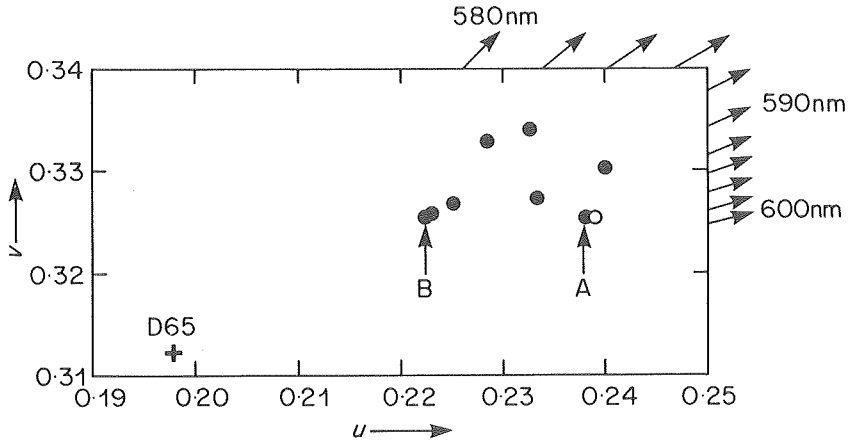

Fig. 4 - Chromaticities of facial area of Test Card 61 and eight flesh tone test colours in D_{65} illuminant

● . . . Test Colours

○ . . . Test Card 61

Arrows round border show dominant wavelengths in steps of 2 nm

portrayed on the card should be black in order to detect small errors in black level during the flesh tone balance procedure. Attempts to achieve true neutrality in hair colour and at the same time retain a natural appearance proved impracticable and the final card shows a model with dark brown hair. It is thought that if a black level reference is required, suitable chips from a Test Chart 57 may be attached to the card, but these are not provided as part of the Test Card 61 itself as some operators found their presence distracting when carrying out the flesh tone balance.

The background to Test Card 61 is not strictly neutral but the departure from neutrality is small and the reflectance (to white light) is substantially constant over the whole background area. Attempts to make the background accurately neutral and of uniform reflectance again detracted from the overall naturalness of the picture which was considered an essential feature of the Test Card.

Test Card 61 is prepared using conventional printing inks which will undergo changes in spectral reflectance characteristics with time, particularly if exposed to ultra-violet radiation. In the period of studio trials, however, no colour changes have been noticed. It is therefore likely that, if used entirely in tungsten lighting (which contains little ultra-violet) the life of a Test Card 61 will be comparable with that of the Test Chart 57 grey scale and may well be determined by damage to the card rather than by colour changes. To prolong its life the card should not be exposed to light unnecessarily. The appearance of colour changes may well be accelerated if the card is exposed to daylight for significant periods or used in conjunction with lights (e.g. metal halide discharge lamps) having a higher ultra-violet content than tungsten illumination.

6. Conclusions

Test Card 61 has been designed to present as natural a portrayal as possible of a human subject on a colour television display, so that a sensitive flesh tone colour balance may be carried out between the cameras in a studio. The spectral reflectance characteristics of human skin have been reproduced in the test card as accurately as possible. By angling the card downwards by about twenty degrees the appearance of specular reflections from studio lights is minimized.

The excellent uniformity of the cards should enable an accurate flesh tone reference to be maintained by the Television Service.

In the absence of exposure to ultra-violet radiation during use, and by avoiding unnecessary exposure to light, the card should have long life, probably comparable with the Test Chart 57 grey scale.

7. Acknowledgements

The production of Test Card 61 has primarily been the responsibility of Television Operations and Maintenance Department, Studio Capital Projects Department and the printers W.R. Royle and Sons Ltd. Research Department has advised on the colorimetric and other optical aspects of the chart. In producing the final version of Test Card 61 many discussions were held between production staff, specialist staff and the printers and numerous studio trials were made with the prototype cards. This final version represented, inevitably, a compromise between the various engineering and production requirements. Helpful information was obtained from P.I.R.A. at Leatherhead (the Research Association for Paper Board, Printing and Packaging), from printers and from the manufacturers of printing equipment.

8. References

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